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NASA Contract NAS8-31689
DR SE-03-A

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Volume 4

Specifications

November 1976

Part 1
AMPS Program Specification

Atmospheric,
Magnetospheric and
Plasmas in Space
(AMPS) Spacelab
Payload Definition
Study

(NASA-CR-152558) ATMOSPHERIC,
MAGNETOSPHERIC AND PLASMAS IN SPACE (AMPS)
SPACELAB PAYLOAD DEFINITION STUDY. VOLUME

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4. PART 1, AMPS PROGRAM SPECIFICATION

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Volume 4

Specifications

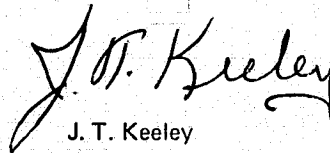
November 1976

Part 1
AMPS Program Specification

**ATMOSPHERIC, MAGNETOSPHERIC
AND PLASMAS IN SPACE (AMPS)
SPACELAB PAYLOAD DEFINITION
STUDY**

Prepared for

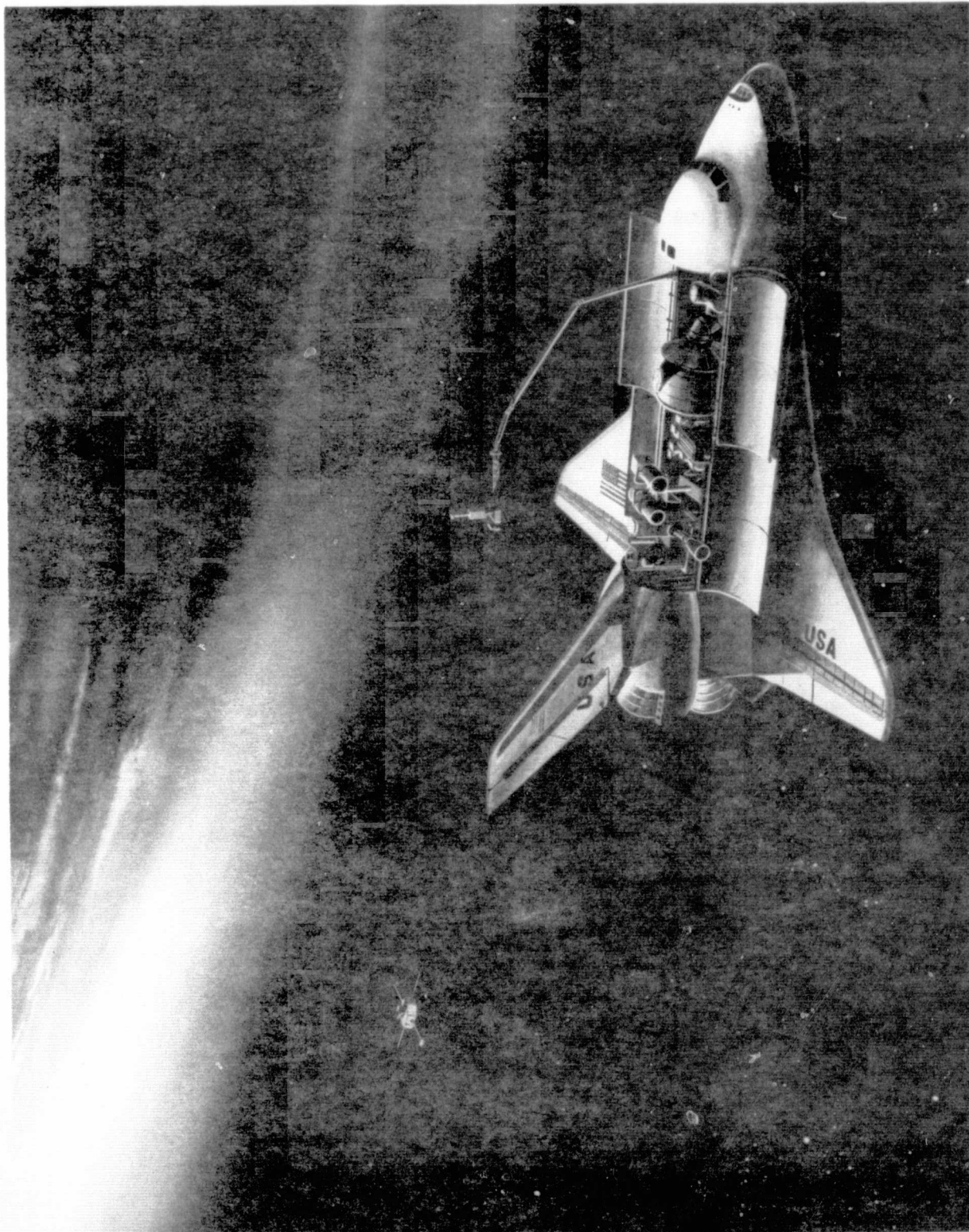
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FOREWORD

The AMPS final report is submitted by Martin Marietta in accordance with Data Procurement Document Number 486, Revision A, of Goddard Space Flight Center Contract NAS8-31689.

The AMPS final report consists of seven volumes. They are:

Volume 1	DR MA-05-A	Executive Summary Report
Volume 2	DR SE-01-A	Mission Support Requirements Document
Volume 3	DR SE-02-A	Interface Control Documents
	Part 1	AMPS Payload to Shuttle ICD
	Part 2	AMPS Payload to Spacelab ICD
	Part 3	AMPS Payload to Instruments ICD
Volume 4	DR SE-03-A	Specifications
	Part 1	AMPS Program Specification
	Part 2	AMPS Payload General Specification
	Part 3	AMPS Instrument Systems General Specification
Volume 5	DR SE-04-A	Deleted per Paragraph I, Attachment A, Request for Proposal under Changes Clause, dated 8/31/76
Volume 6	DR SE-05-A	Instruments Functional Requirements Document
Volume 7	DR MA-04-A	Program Analysis and Planning for Phase C/D Document
Volume 8	DR MF 003R-A	Program Study Cost Estimates Document

PROGRAM SPECIFICATION

(LEVEL II)

ATMOSPHERIC, MAGNETOSPHERIC, AND PLASMAS IN SPACE

(AMPS)

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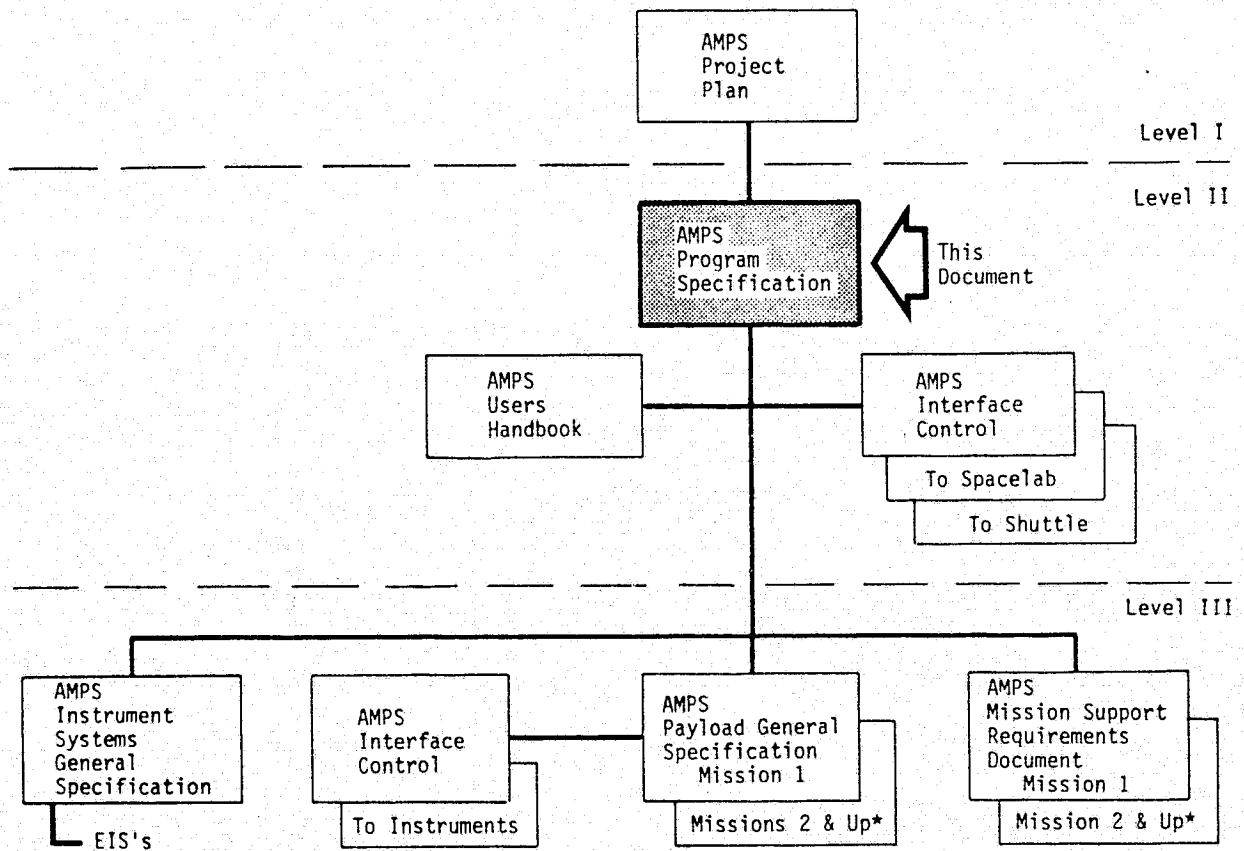
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1. SCOPE

The AMPS PROGRAM SPECIFICATION (this document) delineates the AMPS PROGRAM requirements consistent with the resources defined in the AMPS PROJECT PLAN. All subsidiary specifications and requirements shall conform to the requirements herein.

The requirements hierarchy for the AMPS program is illustrated in Figure 1.1. A brief description of each of these documents and their intended use is provided below.



* Reissue or Addenda, depending on magnitude of change.

FIGURE 1.1 AMPS TOP LEVEL REQUIREMENTS TREE

AMPS Project Plan (PP) - This plan governs the programmatic aspects of AMPS and includes the organizational and management roles and responsibilities, planning and control requirements, resource allocation, and implementation requirements.

AMPS Program Specification (PS) - This specification establishes the overall scope and operational boundaries for the entire program. Additionally it defines the goals, guidelines and approaches to be followed in the lower level detailed design and performance specifications and requirements documents.

AMPS Payload General Specification (PGS) - This specification contains the prime contractor's top level requirements for the delivery of the flight and ground support equipment, software and integrated AMPS/LABCRAFT payload. It specifies and defines the physical and functional characteristics of the deliverable items consistent with the Program Specification.

AMPS Mission Support Requirements Document (MSRD) - This document defines the experiment objectives, instrument requirements, and documents the total ground and mission requirements to be implemented by GSFC and other NASA centers for each AMPS/LABCRAFT mission.

AMPS Instrument Systems General Specification (ISGS) - This specification provides the top level requirements, constraints and guidelines for the definition, development, and integration of the AMPS/LABCRAFT instrument hardware and forms the basis for the preparation of the individual End Item Specifications (EISs) required for procuring the instrument hardware.

AMPS Interface Control Documents (ICDs) - These documents define and control the physical, functional, and operational interfaces between the AMPS, Orbiter, and Spacelab.

AMPS User's Handbook (UH) - This document defines the payload capability and is primarily used to advertise that capability to scientists, universities, etc, planning to utilize the facility for experimentation purposes.

Note that the requirements hierarchy shown provides adequate technical control for the first mission and also makes provision for configuration and operations variations anticipated for follow-on missions (2 and up) with minimal or no change to this document.

2. APPLICABLE DOCUMENTS

The following documents, of the exact issue shown, form a part of this Requirements Document.

<u>APPLICABLE DOCUMENT NUMBER</u>	<u>TITLE</u>
---	--------------

- | | |
|----|--|
| 1. | Space Shuttle System Payload Accommodations, JSC 07700,
Vol. XIV, Rev D, Change 16. |
| 2. | Spacelab Payload Accommodations Handbook, ESTEC, SLP/
2104, May, 1976. |
| 3. | Spacelab GSE Allocation and Requirements Plan, MSFC,
40A99005, June 25, 1976. |
| 4. | Spacelab GSE Items Description Document, MSFC, 40A99006,
June 25, 1976. |

APPLICABLE
DOCUMENT
NUMBER

TITLE

5. KSC Launch Site Accommodations Handbook for STS P/Ls,
K-STSM-14.1, June 1976.
6. Safety Policy and Requirements for Payloads Using the
National Space Transportation System, NASA HQ,
June 1976.
7. Safety, Reliability, Maintainability, and Quality Pro-
visions for the Space Shuttle Program, NHB 5300.4
(1D-1), August 1974.
8. Baseline Operation Plan, JSC (TBD).
9. Specification, ARINC-404A, Air Transport Equipment Cases
and Racking, 15 March 1974.
10. Military Standard, Human Engineering Design Criteria
for Military Systems, Equipment and Facilities,
MIL-STD-1472A, 15 May 1970.
11. Space Shuttle System Pyrotechnic Specification, JSC-0806A.

3. REQUIREMENTS

3.1 PROGRAM DEFINITION

The basic objective of the AMPS program is to achieve an understanding of the physical processes that control mankind's near-earth space environment. The regions encompassed by AMPS investigations include the atmosphere, the ionospheric plasma, the magnetosphere, and

the solar electromagnetic and particle emissions, all of which interact as parts of a coupled, dynamic system. AMPS studies emphasize the investigation of those complex physical processes, characterized by widely varying spatial and temporal scales, which determine the dynamical behaviour of the closed-loop solar wind/magnetosphere/ionosphere/atmosphere system. Those processes that are responsible for the transfer and distribution of energy, mass and momentum from the sun to the earth are addressed by AMPS through the combination of a variety of powerful experimental techniques, including instruments for active injection of particles, waves and plasma, a comprehensive array of highly sensitive, remote-sensing optical instruments, and a number of in situ plasma diagnostic devices.

Specific scientific mission goals generated for AMPS provide timely data for the assessment of urgent problems that affect the practical concerns and needs of mankind. Proposed studies include investigations of both natural and man-made disturbances within the magnetosphere and atmosphere which disrupt the everyday activities of terrestrial life. An example, dramatically emphasizing such disturbances, has been the concern over the effects of man-made catalytic agents, such as the nitrogen oxides and chlorine compounds, on the potential destruction of naturally occurring stratospheric ozone and its resulting impacts. A thorough understanding of such phenomena and their potential impact on terrestrial life, as well as recommended corrective courses of action, may be developed from AMPS studies. The investigation of these and other physical processes bear not only on man's practical needs, but also the intellectual desire for an improved understanding of the processes which govern the nature of our universe.

3.1.1 GENERAL DESCRIPTION

The AMPS program includes the definition, design, development, and operation of reusable payloads to be flown on Space Shuttle flights as Spacelab payloads, and their associated data acquisition, reduction, and analysis. These payloads will provide the capability of operating as a laboratory in space with multiple flights per year. AMPS program elements (described below) will be developed by various sources and will, during the operational phase, become part of the total AMPS capability.

Major program elements include the following:

- a. Science Program Definition - Incremental activities including Announcement of Opportunity, investigation proposals, experiment selection, and top-level requirements development for AMPS missions.
- b. Instrument Development - Acquisition of scientific related flight hardware to perform in situ diagnostics, remote sensing, and active probing of the near-earth environment per the Science Program Definition.
- c. Support Equipment Development - Acquisition of AMPS peculiar Labcraft equipment to supplement STS and multi-program support capability required to accommodate the AMPS instruments and implement the required flight and ground operations.
- d. Software Development/Integration - Activities associated with integrated requirements definition, package development and verification for computer programs required for orbital operations, ground checkout, and data reduction.

- e. AMPS Spacelab Hardware - Spacelab hardware elements which are utilized for the AMPS program, such as pallet segments, module equipment racks, and selected mission dependent equipment.
- f. Hardware Integration/Ground Operations - Activities required for hardware integration, checkout, testing, maintenance, refurbishment, logistics, and launch/post-landing support.
- g. Mission/Flight Operations - Activities involving the mission planning, crew training, readiness simulations, communications, monitoring and control related to on-orbit and post-flight data acquisition, reduction, and analysis (science and engineering).
- h. Systems Engineering and Integration - Activities required to assure that individual end-items and program elements develop and perform compatibly. Typical areas of activity include requirements definition, interface analysis, and control, coordination of support elements external to the program, and other interdisciplinary functions (e.g., safety, R&QA, etc).
- i. Facilities - Buildings and fixed contents required to support AMPS payloads through all phases of operations.

Figure 3.1 illustrates the general flow of activities for the first and succeeding missions. As illustrated, a compatibility assessment will be performed for each scientific mission, comparing preliminary payload requirements against known Space Transportation System and program capabilities (i.e., Orbiter, Spacelab, Multi-Use Mission Support Equipment, GSE, Facilities, Software, etc). Where incompatibilities are found to exist they will be reconciled. Firm requirements derived

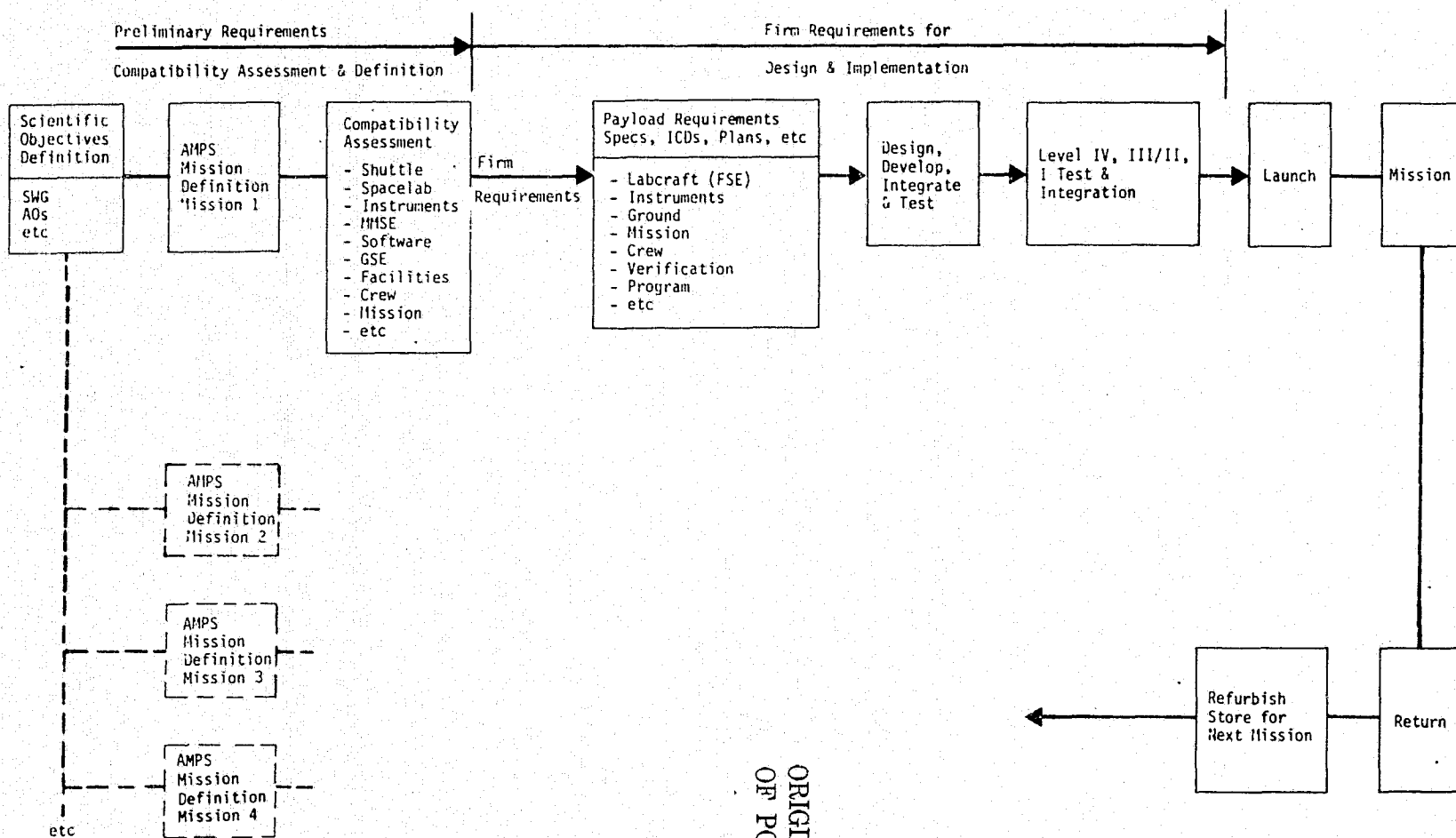


Figure 3-1 AMPS General Activity Flow

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from the compatibility assessment will be baselined in the AMPS-PGS and MSRDs, EISs, and appropriate integration and implementation plans. From these requirements the Labcraft flight support equipment, GSE, software, etc., will be designed, developed and tested; then integrated into a total payload for systems checkout, launch, mission, and return. The returned equipment will be refurbished and stored. Subsequent missions will utilize the equipment as necessary and in addition provide new or modified equipment to satisfy that mission. It is expected that the total AMPS capability will be incrementally developed over the life span of the AMPS program.

3.1.2 SCIENCE PROGRAM DEFINITION

The definition and coordination of AMPS scientific investigations will be a continuing incremental process conducted for successive missions or mission blocks under the joint control of the NASA Headquarters and GSFC. The key elements in the process shall include:

- a. Release of an "Announcement of Opportunity" (AO) to the scientific community. The release will be for specific missions or blocks of missions and will include guidelines on the science objectives and a "User's Guide" to inform potential experimenters of the capabilities and constraints of the payload facility.
- b. Proposal generation in response to the AO by investigators or by science teams.

- c. Proposal evaluation and selection by a "Peer Group Selection Committee" appointed by the NASA Headquarters Program Office.
- d. Effort by GSFC to develop the detailed program and payload requirements to implement the proposed investigations. Included in this effort are the Experiment Requirements (Appendices to AMPS-MSRD); preparation of the individual instrument EISs for instrument procurements and ICDs for instrument to payload interface control.
- e. Program reviews by GSFC to determine schedules, mission selection and to critique, concur and baseline instrument and experiment requirements.

3.1.3 INSTRUMENT DEVELOPMENT

GSFC shall have the overall responsibility for instrument development and will supply to the payload integration contractor all instruments as Government Furnished Equipment. Exceptions to this rule will be off-the-shelf sensors, sensor packages in multi-equipment modules, and other payload unique type instruments. The development requirements for these exceptions will be documented and controlled in the PGS, while the development requirements for other instruments will be documented and controlled by individual "End Item Specifications" based on the AMPS-ISGS. See Figure 1.1.

Instrument and sensor test and certification will be performed either by GSFC, the instrument developer or the payload integration contractor depending on the complexity of instrument and the capabilities of the developer.

Interface control between the instruments and sensors and the Flight Support Equipment (FSE) will be controlled by ICDs. See Figure 1.1. The ICDs will be prepared and maintained by the payload integration contractor with input and signature concurrence from the instrument developers.

3.1.4 SUPPORT EQUIPMENT DEVELOPMENT

The program goal is to minimize the AMPS unique flight and ground support equipment development. Pursuant to this goal equipment shall be developed by AMPS only if AMPS performance and availability requirements cannot be satisfied by the STS capability and the following equipment sources:

- a. Multi-Use Mission Support Equipment (MMSE);
- b. Labcraft;
- c. Other NASA/DOD Programs; and
- d. Commercially Developed.

Planned availability of all multi-use equipment shall be closely monitored so that minimum risk to AMPS can be maintained for equipment outside the AMPS program control.

3.1.5 SOFTWARE DEVELOPMENT/INTEGRATION

The overall approach to AMPS software development shall maximize the commonality of use among GSE/test, mission simulation/operations, and flight. The AMPS Software Development Plan (TBS Phase C/D), shall delineate the detailed approach that assures:

- a. Requirements are defined, integrated, and coordinated consistent with major program review milestones and compatible with STS host capability;
- b. Design, development, and verification proceeds in an efficient, controlled, and visible manner; and,
- c. Modifications, additions, and evolution for successive missions are incorporated with minimum rework.

Figure 3.2 summarizes the AMPS software development cycle, including activities, products and steps within the verification, validation, and certification phases.

3.1.6 HARDWARE INTEGRATION/GROUND OPERATIONS

AMPS ground operations shall be performed consistent with the integration flow illustrated in Figure 3-3 and as defined herein. Program interfaces and responsibilities shall be as defined in Section 3.7 and 4.1.1. Detailed planning and support requirements for specific payloads shall be defined in subsidiary requirements documents and plans and shall be compatible with Applicable Document No. 5.

3.1.6.1 STS INTEGRATION LEVELS

- a. Level IV - Integration and checkout of AMPS Labcraft equipment with individual instruments (e.g., FSE, racks and pallet segments).
- b. Level III - Combination of AMPS integrated pallets and other Spacelab elements to form the AMPS Spacelab Payload.

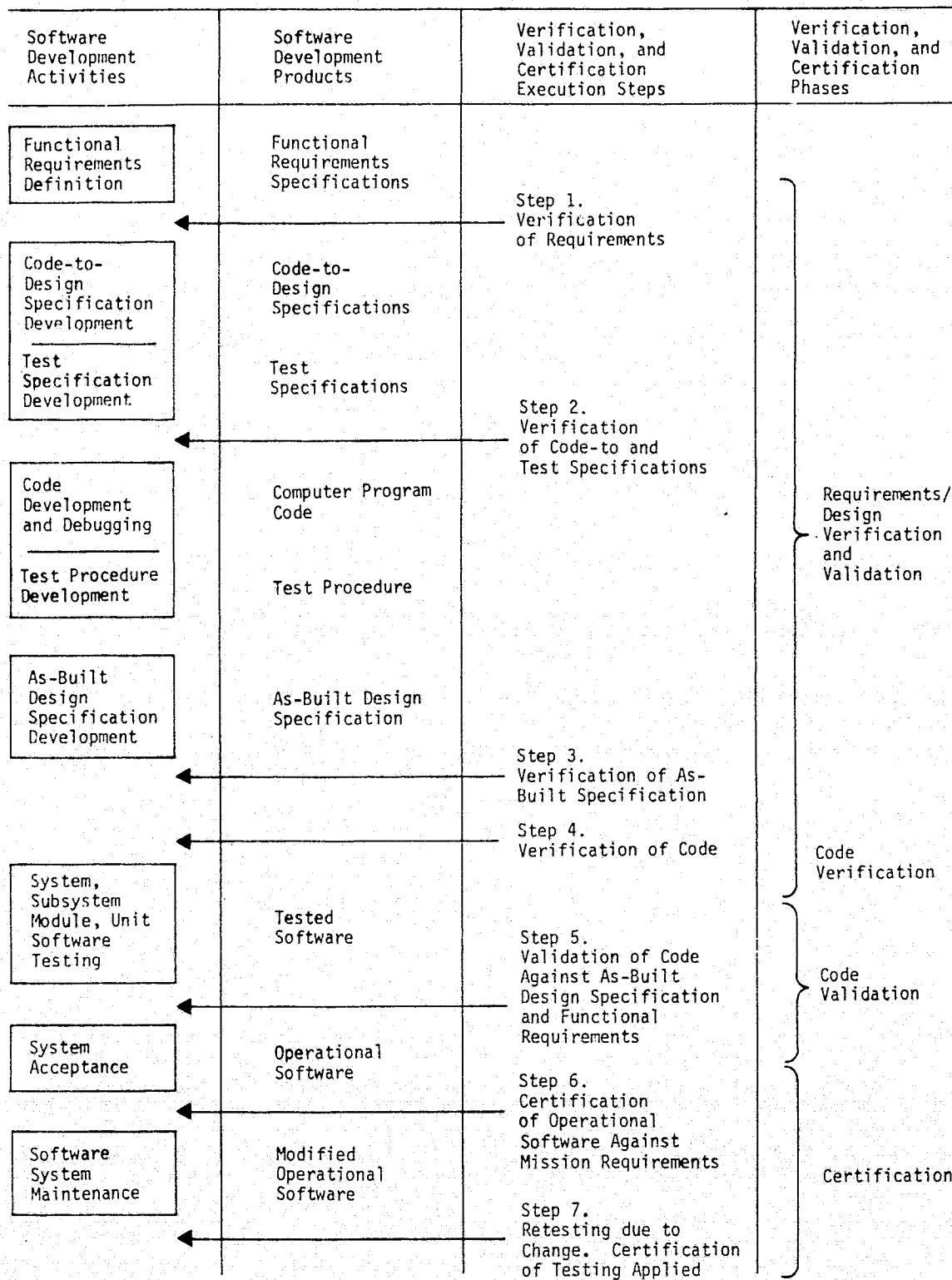


Figure 3-2 AMPS Software Development Cycle

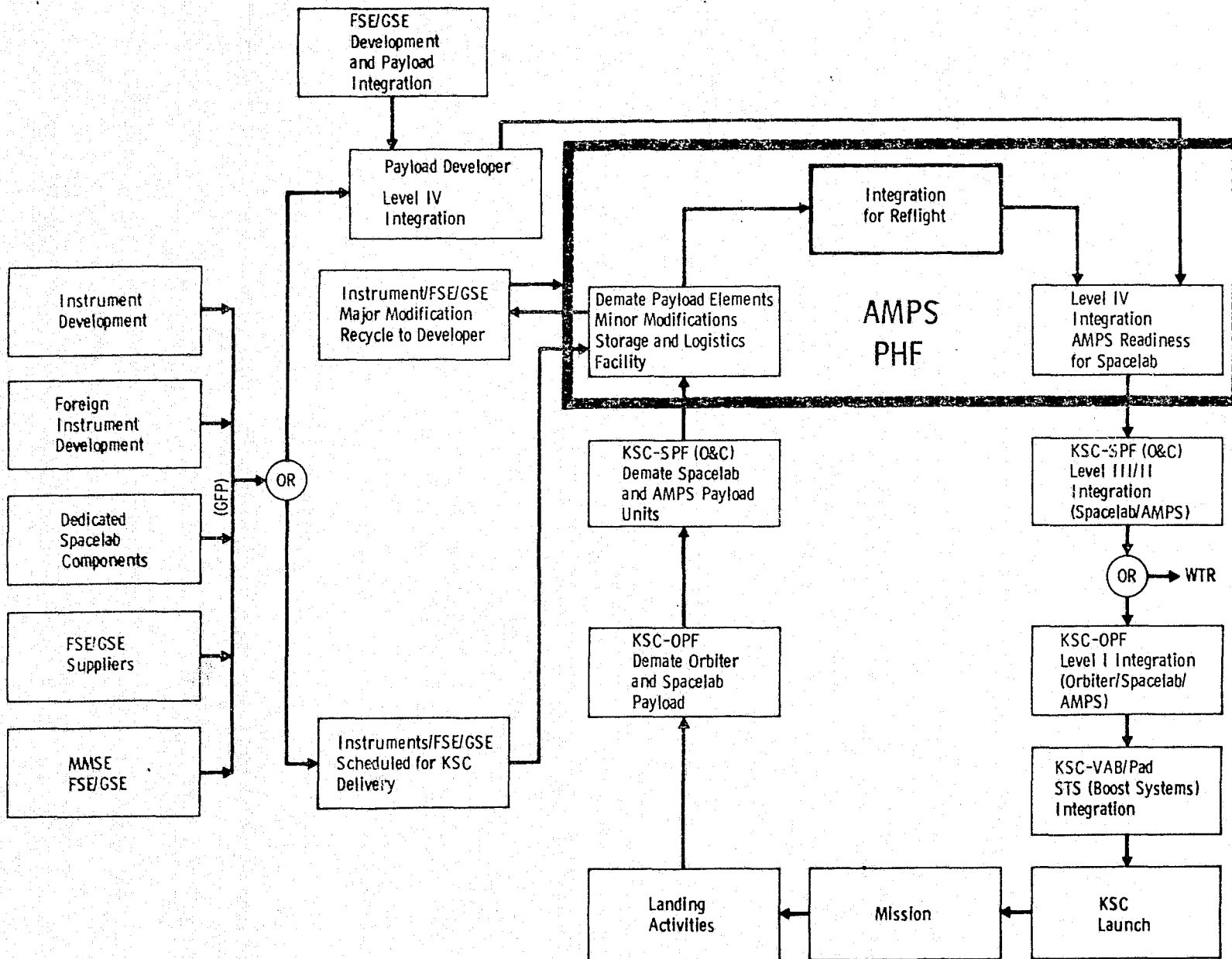


FIGURE 3.3 AMPS GROUND OPERATIONS FLOW

- c. Level II - Integration and system testing of the combined AMPS Spacelab payload in preparation for mating with the Orbiter.
- d. Level I - Integration and checkout of the AMPS Spacelab payload with the Shuttle Orbiter, including the necessary preinstallation testing.
- e. Post-Flight Processing - Landing and safing operations, removal from Orbiter, disassembly, maintenance and reverification of support systems and instruments.

3.1.6.2 AMPS ACTIVITY SUMMARY

Level IV integration activities are to be accomplished at the prime contractor's facility and at the AMPS Payload Handling Facility (AMPS-PHF) at KSC as specified in the AMPS Payload General Specification. Exception to this shall be considered only when approved by the AMPS program manager. Activities at the prime contractor's facility include, but are not limited to:

- Instrument/FSE Receiving/Inspection;
- Installation of Equipment onto Spacelab Pallets and Racks;
- Verification of Instrument/FSE/Software/AMPS Interfaces; and,
- Initial Acceptance AMPS Payload Assemblies.

Following completion of Level IV activities at the prime contractor's facility, AMPS flight and ground equipment shall be transported to KSC for Level IV final integration activities in the AMPS Payload Handling Facility (APHF). Level IV activities culminate in the verification of readiness to go on-line with Spacelab and orbital ground

operations. General activities are associated with connection and verification of all remaining AMPS interfaces and systems performance using simulated Spacelab systems.

AMPS goes on-line with STS operations with Level III/II activities and is in a supporting role to the STS organizations. Applicable Document No. 5 describes this role. The "user" shall be interpreted as the GSFC AMPS project with support provided from the various instrument contractors and integrated by the prime contractor. Major AMPS related activities include:

- Performance of Flight Software Confidence Checks;
- Powered Functional Interface Verification;
- EMC/EMI Testing;
- Mission Sequence Simulation;
- Integrated Mission Simulations (with MCC/POCC) and with Flight Crew;
- Installation of AMPS Ordnance/Pressurized Equipment;
- Weight and Center of Gravity Checks; and,
- Spacelab Close Out.

Similarly, Level I integration is the responsibility of the STS and is supported by AMPS. Following Orbiter closeout, AMPS shall be in a flight readiness mode. The remainder of the launch support activities are oriented to the assurance that readiness is maintained. AMPS related activities include:

- Spacelab/Orbiter Interface Verification;
- Time-Critical Stowage;
- C&D Configured for Launch;

- Orbiter Bay Close Out; and,
- C&W Monitoring Through Launch.

The landing of the Orbiter at mission completion initiates the payload demating sequence. After the post-landing activities on the landing strip the Orbiter is moved to the OFF and the AMPS Spacelab payload is demated from the Orbiter and transported to the SPF where the Spacelab is demated from the AMPS elements. The AMPS elements are then transported to the AMPS-PHF for maintenance and refurbishment.

Maintenance, refurbishment, and integration for reflight starts with the demating of the P/L elements for:

1. Shipment to the developer for major modification;
2. Repair or minor modification on site; or,
3. Preparation of "remain-as-is" elements for storage until required.

The AMPS P/L integration sequence (Figure 3.3) shall be followed for each subsequent mission.

3.1.7 MISSION/FLIGHT OPERATIONS

The flight operations activities for the AMPS program are illustrated in Figure 3-4 and discussed below. The primary requirement shall be to make maximum use of STS-developed techniques, facilities, and equipment, and to augment these with a minimum of payload peculiar items. Detailed planning and support requirements for specific missions shall be defined consistent with Applicable Document No. 8.

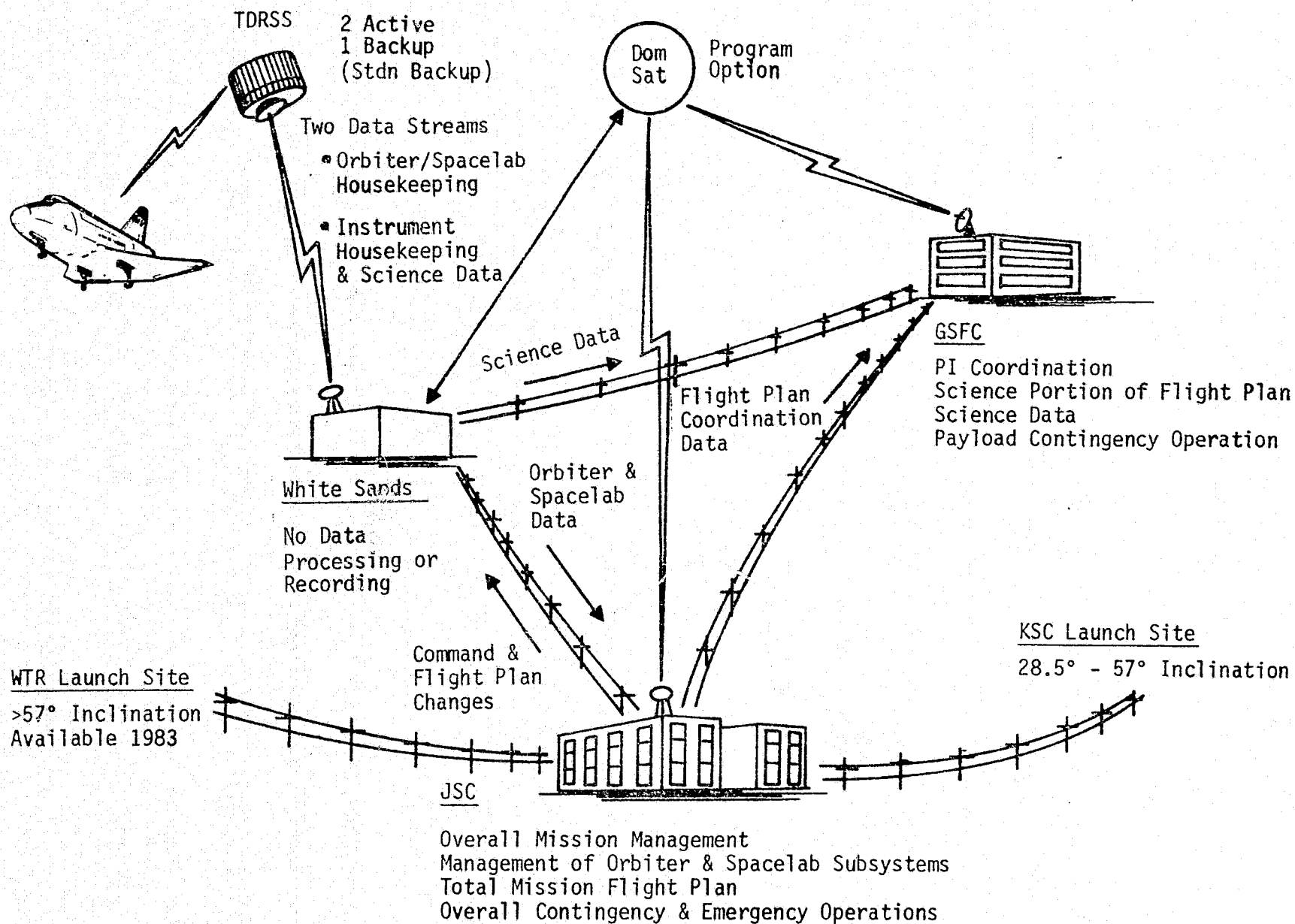


Figure 3-4 AMPS Mission Operations

3.1.7.1 FLIGHT PLANNING

Pre-mission flight plans shall be developed jointly by the Payload Operations Center (POC) and the STS Operations Center. The POC shall be responsible for the overall science objectives and planning while the STS Center will be responsible for the integrated STS/AMPS flight plan. As referenced herein, the POC includes support from principal investigator, instrument developer, and the prime contractor.

3.1.7.2 CREW PROCEDURES

STS peculiar crew procedures shall be developed by the STS operations center while the AMPS Flight Support Systems (FSS) procedures and the experiment procedures shall be developed by the AMPS POC/prime contractor with inputs from the AMPS instrument developers and integrated by the prime contractor.

3.1.7.3 FLIGHT CREW

The AMPS flight crew shall normally consist of a commander, pilot, one or two mission specialists and two to three payload specialists. The commander, pilot and mission specialists are career astronauts highly qualified in Spacelab operations and supplied to AMPS by the STS operator (JSC). The payload specialists include the onboard scientific team leader selected, trained and supplied by the payload center (GSFC), he/she may be qualified astronauts at GSFC discretion. The

STS/peculiar training and crew operations is the responsibility of the STS operator. Mission peculiar training and operations are the responsibility of the AMPS project.

3.1.7.4 FLIGHT CONTROLLERS

The Mission Control Center (MCC) at JSC provides overall mission control of the STS/Spacelab AMPS flight. JSC provides all STS/Spacelab subsystem flight controllers. AMPS will provide AMPS FSE/experiments flight control specialists to JSC during simulation and real time mission operation. AMPS flight controllers will staff the POCC assisted by designated scientists and cognizant hardware engineers. Mission contingency support at the MCC and POCC will be augmented by AMPS contractors and principal investigator home facilities as directed by the AMPS project.

3.1.7.5 DATA RETURN

Electronic data return shall be via tape, down linked via TDRSS, or down linked via STDN. Other forms of data shall be stowed in their raw state for post-landing retrieval.

3.1.7.6 DATA PROCESSING/DISTRIBUTION

The STS operations center will process all STS and Spacelab operational data while the AMPS POCC shall process and distribute all AMPS

housekeeping and science data including real time, near-real time, and non-time critical post-mission data based upon the mission peculiar AMPS Integrated Data Requirements Document (TBS Phase C/D).

3.1.8 SYSTEMS ENGINEERING AND INTEGRATION

The AMPS program shall establish and control project and system requirements. Project specifications will be developed and maintained in accordance with the top-level requirements tree shown in Section 1 (Figure 1-1). This document tree portrays, in a top-level manner, the specifications and requirements documents for AMPS design, development, integration and operation. For each of the three major requirements or specifications documents there will be corresponding management and development plans consistent with information management requirements in Section 3.1.9.3.

Activities within this element of the AMPS program shall be accomplished to assure:

1. Detailed definition of requirements for design, development, production, test, and integration comprising the AMPS program;
2. Analyses are performed to support design and to verify compatibility of designs with requirements;
3. Control and direction of engineering for the design and integration of AMPS payloads and recurring operations; and,
4. Technical support is provided to program management functions (Section 3.1.9).

3.1.9 PROGRAM MANAGEMENT

Program interrelationships are defined in the AMPS PROJECT PLAN. The following sections shall serve as a guide for all program participants in assuring that critical program functions and activities are defined and consistently implemented.

3.1.9.1 PROGRAM PLANNING AND ANALYSES

An integrated AMPS Planning and Analyses System shall be established that assures consistent and effective management at all levels of program development and operation.

3.1.9.2 CONFIGURATION MANAGEMENT

An AMPS Configuration Management System shall be implemented which will define the configuration of hardware/software at any point in time throughout the life of the program. The system must provide for the identification of program requirements and system configuration baselines, the control, accounting and tracking of changes to these baselines, a progressive verification that requirements are being properly implemented and that the as-built configuration or hardware/software agrees with the current configuration baselines.

A series of formal system level program reviews shall be conducted by the Program Office, with appropriate NASA Headquarters participation, in order to establish formal program baselines which will represent approaches authorized by NASA for the development of Level I and Level

II requirements solutions. These formal program reviews will include, as a minimum, a Preliminary Design Review, a Critical Design Review, and Space Shuttle System Flight Readiness Reviews.

3.1.9.3 INFORMATION MANAGEMENT/DOCUMENTATION

The AMPS program has the goal of minimizing the documentation required; however, this goal is not intended to compromise or impede effective communication. An information management approach shall be established that provides for clear, nonredundant sets of documentation, developed consistent with required availability and format suitable for their intended purpose.

3.2 FUNCTIONAL CHARACTERISTICS

3.2.1 MISSION/EXPERIMENT OPERATIONS

The current baseline missions and their requirements for the AMPS program shall be delineated in the appropriate Mission Support Requirements Documents (AMPS-MSRD) and their appendices. Updated requirements for successive follow-on missions will be contained in a re-issue or addenda to the AMPS-MSRD and appropriately reflected and controlled throughout the other program documentation. The AMPS-MSRD shall include requirements consistent with performing the activities described in Section 1.

3.2.2 INSTRUMENT SYSTEMS

3.2.2.1 GENERAL

The AMPS instrument systems shall provide the scientific investigative functions for each mission/experiment operation. The specific instrument functional characteristics shall be developed as a part of the procurement specification and shall be consistent with the appropriate Interface Control documents. Specific requirements shall be developed to satisfy multiple mission use when multiple use is identified in the baseline missions. The requirements shall reflect appropriate design margins, capability of simple modifications, or a combination of both. Consideration for increased performance to cover missions not in the baseline shall be by AMPS program manager approval only.

3.2.2.2 ALLOCATION OF PERFORMANCE

Allocation of performance requirements will be determined by trade studies and analyses and the AMPS program office. As an example, if several instruments required common support, it may be beneficial to supply a common capability rather than several individual capabilities. For these cases it shall be the responsibility of the AMPS program office to define the procurement approach (i.e., procure as part of the instrument or a Labcraft).

3.2.3 FLIGHT SUPPORT SYSTEMS

The integrated capability of the AMPS support systems is obtained through the combined functions of the Shuttle, Spacelab, MMSE, Labcraft, and AMPS unique equipment.

AMPS payloads shall have the capability of being flown on the Space-lab/Orbiter to a wide range of orbits and inclinations (28.5° to polar) and be modular so that elements can be flown in conjunction with other payloads, or on different AMPS flights. The AMPS systems shall have the capability to accommodate new and upgraded instruments, support equipment, and experimental concepts over the life of the project.

AMPS flight equipment shall be designed for maintenance and refurbishment over the life of the project. Specific operational life shall be determined based on the planned usage for the individual end items.

The following sections specify the general requirements applicable to all AMPS equipment and multi-use elements.

3.2.3.1 STRUCTURAL AND MECHANICAL

- a. General - AMPS payload items shall be mounted in the pressurized Spacelab module or on unpressurized Spacelab pallets in accordance with Paragraph 4.1 of Applicable Document No. 2.
- b. RMS Deployment - AMPS payload items that are to be released or deployed by the Orbiter Remote Manipulator System shall have attach points and deployed performance requirements that conform with Paragraph 8, Remote Manipulator System, of Applicable Document No. 1.

- c. Automated Deployment and Retraction Equipment - Equipment or components that deploy outside the Orbiter payload dynamic envelope shall have backup capable of being manually retracted or separated from the payload without contacting the payload or Orbiter during initial separation or subsequent orbits. Jettison shall be accomplished by one crewman and must satisfy the reliability requirements in Paragraphs 3.4.1 and 3.4.2.
- d. Mounting in the Spacelab Module - AMPS provided mounting structure for mounting equipment in the racks of the pressurized Spacelab Module shall provide for cooling in accordance with Paragraph 4.3.2 of Applicable Document No. 2.
- e. Pallet Mounted Equipment - AMPS provided equipment mounting structure for equipment mounted on the Spacelab pallets shall provide an efficient physical arrangement meeting instrument field-of-view requirements and passive thermal control view factors. For equipment requiring active heat rejection capability mounting structure shall be provided in accordance with Paragraph 4.3.2 of Applicable Document No. 2.
- f. Ground Handling Provisions - AMPS equipment structure shall be designed to facilitate ground handling, checkout and refurbishment of equipment and rearrangement into different flight configurations. The integrated payload shall be capable of horizontal integration with the Orbiter and the removal of individual items in the vertical configuration.
- g. Load Environments - Equipment mounting provisions shall be in accordance with loads derived from the environments identified in Section 3.5.

- h. Physical Characteristics - All AMPS structures shall be designed consistent with physical requirements of section 3.3.
- i. Interfaces - Specific interface support requirements shall be contained in the appropriate instrument, Spacelab and Shuttle to AMPS Interface Requirements Documentation. See Figure 1.1.
- j. Maintainability - Physical location of all AMPS hardware shall provide accessibility to remove, replace, and service the hardware both on a single pallet assembly or a totally assembled payload.

3.2.3.2 THERMAL CONTROL

- a. General - The AMPS Thermal Control System shall be designed to maintain the components within their required temperature limits as defined in the appropriate CEI specifications and ICDs. Also as a design goal, the AMPS thermal control shall utilize the existing Spacelab/pallet and Orbiter thermal control systems to the maximum extent possible. Reference Applicable Document No. 1 and No. 2 for STS capabilities.
- b. Passive Thermal Control - Passive thermal control techniques to be used shall include optimized equipment locations and selection of materials and coatings with physical and surface thermal properties necessary to attain an adequate thermal balance between components, structure and the external environment. Surface finishes shall also provide required electrostatic charge control characteristics.

- c. Active Thermal Control - Active thermal control, where necessary for pallet hard mounted equipment, shall be limited to Spacelab cold plates and thermal capacitors, thermostatically controlled heaters, and cryogenics. Gimbal mounted equipment shall have self-contained systems, or special FSE provisions. Active thermal control of equipment mounted in the pressurized Spacelab module shall be in accordance with the convective cooling capability defined in Paragraph 4.3.2.1, Cabin Air Loops, or the Experiment Heat Exchanger defined in Paragraph 4.3.2.3 of Applicable Document No. 2. Heat removal capability shall be within the limits of Paragraph 4.3.3 of Applicable Document No. 2.
- d. Environmental Parameters - The hot and cold thermal environmental parameters used in the AMPS thermal design shall be as follows:

Parameter	Hot	Cold
Solar Flux, W/m^2	1440	1264
Albedo	0.42	0.18
Planetary Flux W/m^2	279	194

The AMPS orbit is circular and the beta angle can vary between zero and ninety degrees. The vehicle normal operation is with the +Z axis earth pointing and either the tail or nose facing the sun (X-POP). The AMPS payload shall be designed to enable solar inertial attitude (Z axis sun facing) for durations as long as one orbit. The orbital altitude varies between TBD and TBD.

- e. Deployed Components - Components deployed external to the Orbiter payload envelope shall have thermal control provisions incorporated in their design to assure acceptable performance during deployed periods for all orientations during the flight and to withstand nondeployed environments during boost and return. These thermal control provisions shall be self-contained and independent of physical interfaces with the remainder of the payload except for the use of electrical power.

3.2.3.3 ELECTRICAL POWER AND DISTRIBUTION

- a. General - AMPS power shall be obtained from Spacelab in accordance with Paragraphs 4.2 and 7.4 of Applicable Document No. 2. Spacelab power available to the instruments include 28 ± 4 volt DC and $115/220 \pm 5\%$ volt 400 Hz three phase AC. All other power requirements shall be supplied by the instruments or AMPS peculiar power conditioning equipment. The power available to the instruments will depend on the power consumption of all mission dependent equipment and mission independent Spacelab subsystems. AMPS Spacelab energy requirements for any flight in excess of 50 Kwh shall be provided by adding Orbiter power kits as defined in Paragraph 9.1, Payload Electrical Energy, of Applicable Document No. 1.

- b. Grounding and Isolation - All AMPS equipment shall be referenced to structure at one point through the Spacelab DC return. All AMPS equipment shall maintain circuit isolation of at least 1 meg-ohm from input power leads to chassis and signal returns to chassis. AMPS equipment grounding and isolation shall be in accordance with Paragraph 4.2.3.4, Grounding, of Applicable Document No. 2.
- c. Circuit Protection - All AMPS equipment shall be provided with positive action circuit breakers or fuses to prevent faults within the equipment from propagating into the Spacelab power distribution system.

3.2.3.4 ATTITUDE AND POINTING CONTROL

- a. Instrument Pointing - AMPS instrument pointing requirements shall be satisfied, to the maximum extent possible, by the Orbiter Vernier Control System (VCS) in accordance with Paragraph 3.2.3, Pointing Accuracy, of Applicable Document No. 1. Instrument pointing accuracy, stability and maneuvering requirements that exceed Orbiter capabilities (rate and propellant usage) shall be satisfied by pointing platforms. Existing or multi-use platforms shall be used whenever practicable.
- b. Attitude Reference - The Orbiter GN&C System shall be augmented with a payload-mounted sensor or sensors to acquire and maintain the appropriate earth or space referenced attitude with respect to the instrument or payload line-of-sight, when required.

- c. Computer Use - AMPS instrument pointing programs and attitude displays shall utilize the computer capability provided by the STS. Supplemental capability shall be considered only if the integrated payload requirements exceed the STS capability.
- d. Positioning - AMPS instruments requiring various positioning (in addition to, or as opposed to pointing and maneuvering) shall be satisfied by the most feasible means considering the Orbiter Remote Manipulator System before adding AMPS peculiar equipment.
- e. Command and Control - The prime mode of controlling instrument pointing/maneuvering/positioning shall be by the flight crew. Limited backup capability to command instrument pointing from the ground shall be provided for instrument where overall performance is enhanced by ground control or where operations are enhanced by relieving the crew of instrument pointing responsibilities all or part of the time.

3.2.3.5 DATA MANAGEMENT

- a. General - AMPS equipment shall, as a prime mode, interface with the Spacelab Command and Data Management System for commands and data processing, displays, recording and multiplexing in accordance with Paragraph 4.4, Command and Data Management Subsystem of Applicable Document No. 2. Dedicated AMPS data processing, computing and recording equipment shall be provided only when the Spacelab capability is exceeded,

communication coverage is insufficient, or interface simplification and cost effectiveness are shown.

- b. STS Systems - The AMPS to Spacelab interface shall include the processing of digital and discrete data, ranging in data rates from DC to 30 Mbps and analog data from DC to 4 MHz, being distributed to the multiplexer, recorders, computer, Orbiter and onboard displays and monitors. The capability shall be provided to receive and process data from fixed payloads, boom-mounted payloads, and from deployed packages. For deployed packages a modularized data system based on a common design shall be considered. A closed circuit TV system shall be provided for limited use by the AMPS payload.
- c. Data Routing - Data retrieval by the experiment data bus/ computer shall be to process and display data for enhancement of experiment operation. In addition the computer shall format and route selected data to the Orbiter for monitoring the status of the payload. The experiment data bus shall also be used to process any combination of science and display data as long as the total data rate does not exceed 100 Kbps.

All other digital data from an instrument shall be routed into the high rate data multiplexer. This data stream shall include housekeeping, science and any pertinent corollary data which will facilitate accurate post-flight data processing.

- d. Status Measurements - Measurements shall be provided in AMPS equipment sufficient for the crew and ground operations to monitor and evaluate the status of systems critical to mission success. These data shall be formatted by the Spacelab

computer and routed to the Orbiter data system. The data rate to the Orbiter shall not exceed 64 Kbps.

- e. Safety Measurements - Measurements provided for assessment of items that affect crew or Orbiter safety shall be instrumented with redundant sensors, an overlay technique or use multiple channels. These measurements shall be hardwired to the caution and warning system or directly to the Orbiter MDM.
- f. Fault Isolation - Measurements shall be provided to isolate failures to items designed for in-flight maintenance or replacement.
- g. Data Loss - The total Orbiter, Spacelab, and AMPS data management system shall be designed and operated to preclude loss of any critical AMPS scientific and engineering data.
- h. Command - All commandable AMPS equipment shall be compatible with Spacelab and Orbiter interfaces as specified in the applicable documents referenced above and shall be implemented by the crew through the Orbiter or Spacelab computers. Ground command may be included for selected functions whenever economical enhancement of the operations is clearly shown. The capability shall be provided to initiate commands to a deployed package from the Spacelab. Commonality of command decoder design shall be considered for deployed packages.
- i. Timing - AMPS timing functions shall originate with the Orbiter Master Timing Unit (MTU) and be provided to AMPS by the Spacelab interfaces (reference Section 4.4.2.1.5 of Applicable Document No. 2). Synchronization requirements, as defined for the Experiment Operations in the MSRD and as reflected in the

appropriate End Item Specifications, shall be satisfied within the STS capability, if feasible, prior to consideration of supplemental AMPS unique capability.

3.2.3.6 COMMUNICATIONS

- a. General - AMPS shall make maximum use of the Spacelab/Orbiter communication capabilities supported by the TDRSS, STDN, and DOMSAT. AMPS shall make use of these facilities for the recovery of payload telemetry and science data, payload commands, experiment related audio, CCTV, and the tracking of remote instruments. Primary support shall be provided by the S and Ku frequency band carriers via the TDRSS; and secondary communications shall be available via S-band links with the STDN ground tracking terminals.
- b. Remote Data Sources - AMPS instruments operating remotely from the Orbiter shall require communications support in the form of data retrieval, ranging and tracking, and command control. The Orbiter RF links to detached payloads shall be considered for providing this support within the available data rate and coverage capability. AMPS requirements beyond this capability shall require the use of dedicated communications hardware which shall be considered part of, and chargeable to, the payload. Remote instrument data retrieved directly by the AMPS payload equipment shall then be subsequently handled in the manner described in 3.2.3.5.

3.2.3.7 CONTROLS AND DISPLAYS

- a. General - AMPS shall make maximum use of existing Spacelab and Orbiter controls (i.e., keyboard entry units) and displays (i.e., CRTs) as defined in Section 4.4 of Applicable Document No. 2 and Paragraph 11.1.3 of Applicable Document No. 1.
- b. Functional Areas - The AMPS Control and Display shall include:
 - 1. Specific Instrument and Flight Support System Control;
 - 2. Selected Data Display;
 - 3. Operation Status Indications; and,
 - 4. Caution and Warning Display.
- c. Integration - Allocation of specific requirements among the potential AMPS and STS elements shall make maximum usage of existing capability and reflect an optimum integration approach based on trade studies and analyses.
- d. Design - AMPS provided controls and displays shall be mounted in the standard racks provided in the Spacelab modules and the Orbiter aft flight deck in accordance with Paragraph 4.1.2 of Applicable Document No. 2 and Paragraph 11.1.3 of Applicable Document No. 1. AMPS supplied C&D panels shall be compatible in design, nomenclature, color coding, etc. with STS requirements contained in (TBD).
- e. Crew Interfaces - The crew interface design shall be in accordance with Applicable Document No. 10.
- f. Circuit Protection - Circuit breakers shall have manual reset capability and shall visually display position status.

- g. Lighting - Console floodlighting, panel lighting and numeric displays shall be controllable in intensity at the panel or console. Lamp testing capability shall be provided.
- h. Manual Override - Controls and displays shall provide the capability for manual override of automatic system deployed beyond the Orbiter payload bay envelope and systems that are critical to mission success or crew safety.
- i. Software - See Paragraph 3.2.5.2.

3.2.3.8 CAUTION AND WARNING

- a. General - The caution and warning system shall be compatible with the requirements established in Paragraph 14.1.7 of Applicable Document No. 1.
- b. Data - AMPS shall supply to the Orbiter/Spacelab Caution and Warning (C&W) System data which is critical to the safety of the Orbiter/Spacelab crew.
- c. Definitions - C&W parameters shall be categorized as emergency, warning, caution, and advisory as defined in Paragraph 4.4.7 of Applicable Document No. 2.
- d. Power - C&W parameter sensor power will be provided by the Spacelab emergency power bus.
- e. Duty Cycle - AMPS C&W system shall function at all times that the equipment is attached to the Orbiter.

3.2.3.9 DEPLOYED INSTRUMENT SUPPORT SYSTEMS

AMPS will require deployed subsatellite systems at various times during the program to accomplish survey/mapping experiments, to transport packages away from the Orbiter, and to transport and maneuver packages away from the Orbiter. As these systems become a part of the Program baseline, maximum use of existing equipment (e.g., satellites, booster stages, etc) shall be the AMPS goal.

Specific functional and performance requirements included in appropriate subsidiary specifications shall consider multiple mission applications similar to that for instruments as defined in Section 3.2.2.1.

3.2.4 GROUND SUPPORT EQUIPMENT (GSE)

3.2.4.1 MECHANICAL GSE (MGSE)

- a. AMPS shall make maximum use of all applicable, existing mechanical Spacelab Ground Support Equipment (GSE) identified and described in Applicable Document No. 3 to support the operational processing activities. These include transportation, receiving inspection, buildup (including experiment installation), Spacelab support for Orbiter servicing and test, subsystem and system tests associated with the Spacelab integration activities required for initial receipt of hardware and subsequent refurbishment activities.
- b. AMPS shall make maximum use of all applicable, existing mechanical Multi-Use Mission Support Equipment (MMSE) identified and

described in Applicable Document No. 5 concerning planned KSC/WTR launch site accommodations for Space Transportation System (STS) payloads.

- c. AMPS peculiar MGSE items identified for new or revised MMSE equipment shall be held to a minimum. New concepts for AMPS MGSE, including preliminary designs, programmatic data (costs and schedules) and development plans shall be prepared to support and justify AMPS recommended end items. Common equipment requirements shall be compared to eliminate duplications.

3.2.4.2 ELECTRONIC GSE (EGSE)

- a. AMPS shall make maximum use of applicable, existing Electronic Spacelab Ground Support Equipment (GSE) identified and described in Applicable Document No. 3 to support the operational processing activities. These include Spacelab support for Orbiter servicing and tests, subsystem and system tests associated with the Spacelab integration activities required for initial receipt of hardware and subsequent refurbishment activities.
- b. AMPS shall make maximum use of all applicable, existing Electronic Multi-Use Mission Support Equipment (MMSE) identified and described in Applicable Document No. 5 concerning planned KSC/WTR launch site accommodations for Space Transportation System (STS) payloads.
- c. AMPS peculiar EGSE items identified for new or revised MMSE equipment shall be held to a minimum. New concepts for AMPS

EGSE, including preliminary designs, programmatic data (costs and schedules) and development plans shall be prepared to support and justify AMPS recommended end items. Common equipment requirements shall be compared to eliminate duplications.

3.2.5 SOFTWARE

AMPS requirements shall be allocated to implementation organizations both internal and external to the AMPS Program. This allocation shall reflect the most feasible approach to the integrated payload implementation. Requirements allocated to external elements (e.g., Shuttle, Spacelab, etc) shall be specified in the appropriate interface control documentation.

3.2.5.1 GENERAL

- a. The overall software development activities shall be defined, documented, and controlled similar to, and consistent with hardware activities.
- b. Software shall be of modular design such that, for successive missions, modules may be added or removed depending upon specific experiment/mission requirements. These additions shall be capable of incorporation without detailed knowledge of the programming language.
- c. Software shall be written in a higher-order language, either HAL-S, GOAL, or FORTRAN.

- d. Emphasis shall be placed on minimizing the separate development of flight and ground software so that maximum commonality of use can be maintained.

3.2.5.2 FLIGHT SOFTWARE FUNCTIONS

The AMPS flight software, developed by AMPS or STS elements, shall, in conjunction with the integrated hardware, perform the following functions:

- a. Generate the onboard commands and provide the necessary control and display information required to activate, check out, monitor and deactivate selected instruments and flight support systems;
- b. Process and execute selected ground command and control functions;
- c. Gather instrument/experiment housekeeping data, format such data for onboard display and/or transmittal to ground stations and/or recorders;
- d. Gather instrument/experiment scientific data, convert this raw data to "meaningful" data as required, format this data for transmittal to the ground and/or recorders;
- e. Provide selected analytical capability that will enhance overall science data return and efficient flight operation.

3.2.5.3 GROUND SOFTWARE FUNCTIONS

Ground software, or flight software used during ground operations, shall perform the following functions:

- a. Support test and checkout for flight and ground support systems as well as instruments. This includes stimulation, simulation and data processing;
- b. Provide representative data, functional simulation and processes for mission readiness training, flight crew task analyses, and selected flight crew training;
- c. Provide analytical and operational tasks for mission support. Categories include analyses, planning, monitoring, and evaluation;
- d. Provide post flight reduction of data returned via tape or downlink. Reduction may include editing, correlation, and formatting. Software required to record down-link data will be provided by NASA common support elements.

3.3 PHYSICAL CHARACTERISTICS

Instruments and support systems are to be located on the Spacelab pallets and within the Spacelab module, or the Orbiter cabin, and as an integrated payload shall incorporate the following characteristics:

3.3.1 ENVELOPES

- a. Dimensions and location of the integrated payload shall

comply with STS accommodations as defined in Applicable Documents No. 1 and No. 2.

- b. Individual items and assemblies that constitute an integrated AMPS payload shall have allocated dimensions/envelopes such that the integrated payload complies with item a, above; as well as, payload field-of-view and operation interference requirements.

3.3.2 MASS PROPERTIES

- a. Total payload weight and distribution for flight are constrained by shuttle design as defined in Applicable Document No. 1.
- b. Weight allocation and management shall be performed such that the overall payloads comply with item a, above. Projected weights corresponding to Critical Design Review Maturity shall be at least 10% below the flight allocation for existing technology end-items and 15% for new technology end-items.

3.3.3 COORDINATE SYSTEM

- a. The AMPS payloads shall use the Orbiter payload coordinate system as it relates to axis designation, orientation, and station location (reference figure 2-5 of Applicable Document No. 1)

- b. Special purpose coordinate systems may be developed for ease of analyses or end-item design. However, clear transformations to the Orbiter reference system (item a, above) shall be included in any multi-discipline documentation.

3.3.4 VENTING PROVISIONS

All AMPS structure and equipment enclosures located in unpressurized areas during on-orbit operations shall be equipped with an open venting system for ascent to vent interior regions into the Orbiter payload bay. See Section 4.2.2 "Flight Environment" of Applicable Document No. 1 for Orbiter payload bay capabilities. Equipment within the habitable areas of Spacelab shall be structurally designed to withstand the differential pressures created by venting or when dumped into the cabin atmosphere shall not create a hazardous effect of failure, e.g., release of toxic, corrosive or flammable materials, or a catastrophic explosion.

3.3.5 EXTERNAL EQUIPMENT SURFACE FINISHES

Exterior surface finishes of all components and structures shall be selected to satisfy thermal control, electrostatic charge control, and contamination control requirements.

3.4 SAFETY, RELIABILITY, AND QUALITY ASSURANCE

3.4.1 SAFETY

The AMPS payload shall be equipped with appropriate protective devices and provisions shall be made to avoid all credible hazards generated by it or its mission peculiar support equipment. No hazards associated with the AMPS operations shall prevent safe termination of the Shuttle mission. The AMPS payloads shall have specific equipment, devices and procedures to protect the payload, Spacelab, Space Shuttle and crew from hazards which may result as a consequence of any AMPS related activities. The intent of the safety provisions of NHB 5300.4 (1D-1) shall be provided for in the AMPS safety program. The applicable safety requirements of the NASA Headquarters "Safety Policy and Requirements for Payloads Using the National Space Transportation System", the Space Shuttle Systems Payload Accommodations (JSC 07700, Vol XIV), the KSC Launch Site Accommodations Handbook for STS Payloads (K-STSM-14.1), and the Spacelab Payload Accommodations Handbook (SLP/2104) (reference Applicable Documents No. 6, 1, 5, and 2 respectively) shall be incorporated in the AMPS design.

3.4.1.1 PYROTECHNICS

All pyrotechnics used in the AMPS payload shall use the NASA Standard Initiator (NSI) and the Pyrotechnic Initiator Controller (PIC). The pyrotechnic devices shall meet the requirements of the Space Shuttle

System Pyrotechnic Specification, JSC 08060A (reference Applicable Document No. 11).

3.4.1.2 PRESSURE VESSELS

All pressure vessels used in the AMPS payload shall be designed in accordance with the standards specified in the NASA Headquarters "Safety Policy and Requirements for Payloads Using the Space Transportation System" (reference Applicable Document No. 6 and Section 8.1 of Applicable Document No. 2). Certain pressure vessels of payloads previously flown successfully on expendable launch vehicles which do not meet the above requirements, may be considered for flight on the STS provided that they have complied with applicable expendable launch vehicle ground safety requirements.

3.4.2 RELIABILITY

The intent of the reliability provisions of NHB 5300.4 (1D-1) (reference Applicable Document No. 7) shall be provided for in the GSFC/AMPS Reliability Program Plan, TBD.

3.4.2.1 CRITICAL SINGLE FAILURE POINTS

AMPS equipment and operations shall be designed so that no single failure can occur that will impact crew safety or result in major degradation (loss of more than 50%) of the scientific experiment capability. No second failure of the same hardware element shall prevent

successful abort of the mission. As a minimum, the AMPS system shall be designed to fail safe.

3.4.2.2 REDUNDANCY

Where redundancy is employed the AMPS design shall include the following:

- a. The capability to check out redundant elements as part of normal ground checkout sequence;
- b. The capability to detect failures of redundant elements during operation; and,
- c. Provisions to minimize the probability that all redundant elements can be lost by a single credible cause of event such as contamination or localized destruction, i.e., isolate the separate redundant elements of the critical components to the maximum extent practical.

3.4.2.3 DEPLOYABLE INSTRUMENTS AND APPENDAGES

All deployable instruments and appendages which could prevent closure of the payload bay doors shall be designed with redundant retraction mechanisms and/or jettison capability. The devices used for jettison of hardware shall be designed with dual or greater redundancy to prevent inadvertant operation during all ground and flight operations. An arm and execute action with provisions to return to a safe condition is required for intentional operation of the devices.

3.4.2.4 MAINTAINABILITY

The AMPS maintainability program shall satisfy the intent of NHB 5300.4 (1D-1) except that maintainability allocations and predictions will not be required. The AMPS payload shall be designed for planned "black box level" maintenance on the ground with the payload not installed in the payload bay. There will be no planned on-orbit maintenance of the AMPS equipment installed on the pallet external to the Spacelab.

3.4.2.5 ACCESSIBILITY

Ground accessibility shall be provided to allow for ease of removal and replacement of components or modules during all ground operations with the payload not installed in the Shuttle payload bay. Provisions shall be made to minimize time and special equipment required for efficient ground maintenance operations. Relatively easy on-orbit access by the flight crew shall be provided for selected AMPS safety and mission critical components or modules located in the pressurized areas.

3.4.3 QUALITY ASSURANCE

The intent of the quality assurance provisions of NHB 5300.4 (1D-1) shall be provided for in the GSFC/AMPS Quality Assurance Plan, TBD.

3.5 ENVIRONMENTS

3.5.1 STANDARD ENVIRONMENTS

The standard natural and induced environments to which the AMPS payload may be exposed are described in the Space Shuttle System Payload Accommodations (Reference Applicable Document No. 1) and the Spacelab Payload Accommodation Handbook (Reference Applicable Document No. 2). These are the environments in the Orbiter payload bay and at the AMPS/Pallet interface outside the pressurized module. These environments are design requirements for AMPS equipment mounted on the pallet and provide the basis for analytical determination of the environments within the AMPS instruments and FSE.

3.5.2 EMI/EMC

Instruments and support equipment shall be designed to be compatible with EMI environmental parameters as specified in Section 5.1.8 of Applicable Document No. 2, specific CEIS's and integrated payload performance requirements.

3.6 END-ITEM DESIGN AND CONSTRUCTION STANDARDS

3.6.1 SELECTION OF SPECIFICATIONS AND STANDARDS

All application of specifications and standards must be approved by the AMPS Program prior to incorporation into this specification and

subsidiary specification. Approval shall be based on specific rationale for inclusion as relates to AMPS goal for low cost approaches. The order of precedence for selection of specification and standards shall be established on merit of specific application from the following:

1. NASA Goddard Space Flight Center specification and standards;
2. Other specification and standards of other NASA centers or NASA Headquarters;
3. Federal specifications or standards;
4. Military specifications or standards;
5. National standardization agency documents;
6. Commercial specifications and standards; and,
7. Contractor prepared specifications and standards.

3.6.2 AREAS OF APPLICATION

The following areas are candidates for standardization of design practices:

- a. Aeronautical;
- b. Electrical;
- c. Mechanical;
- d. Moisture and Fungus Resistance;
- e. Surface Finishes;
- f. Corrosion of Metal Parts;
- g. Non-Metallic Materials Selection;
- h. Parts Commonality;

- i. Identification and Marking;
- j. Human Engineering Criteria;
- k. Workmanship; and,
- l. Producibility.

3.7 PROGRAM INTERFACES

Figures 3-5 and 3-6 illustrate the general AMPS ground operation and flight system interfacing areas, respectively. Interfacing areas of the AMPS Program shall be established and controlled by normal program management procedures including formal documentation, where required. The AMPS Interface Identification Matrix (TBD) is maintained for all formal interfaces by the AMPS Program to serve as the management tool for providing visibility and appropriate emphasis.

The AMPS Program has a multitude of interfaces (physical, functional, procedural) with the STS elements and operations. Some latitude may exist for AMPS peculiar documentation and coordination; however, each responsible STS element has established guidelines and approaches that shall be followed by the AMPS program.

AMPS has the goal to comply with STS established guidelines, but shall emphasize the elimination of duplicate activities and information development.

3.8 CONTAMINATION CONTROL

A contamination control plan shall be prepared and implemented to control the contamination to acceptable levels during designs, manufacturing,

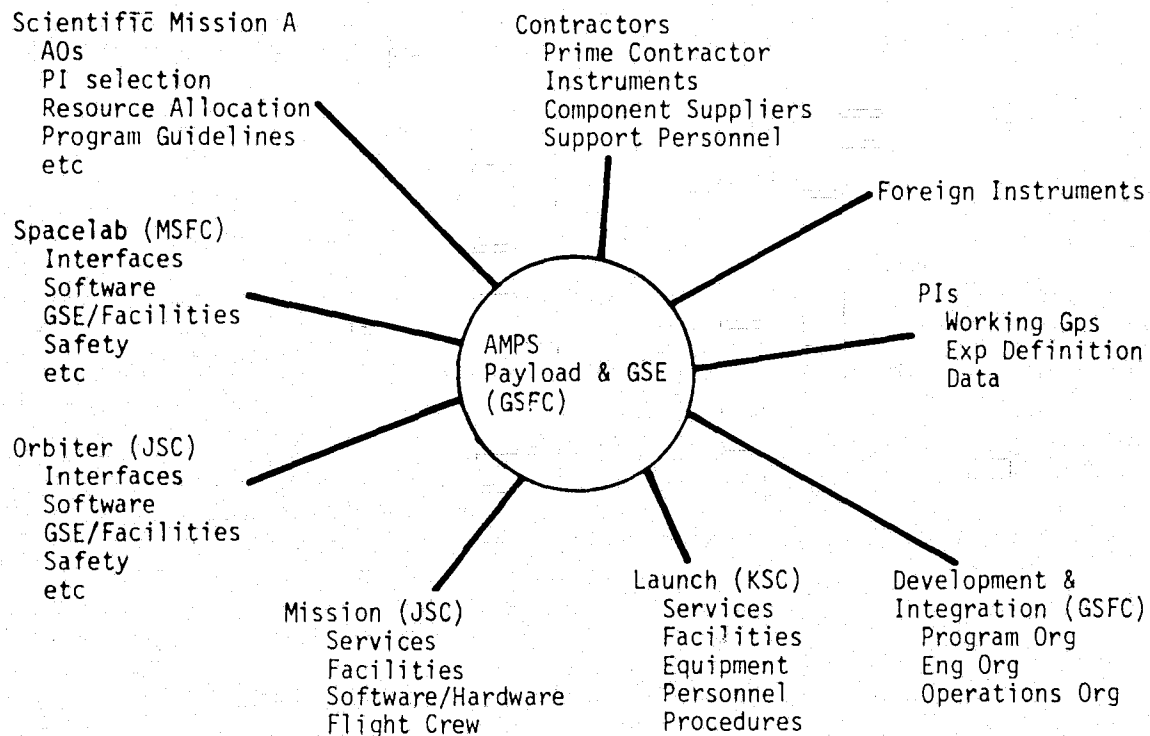


Figure 3-5 AMPS Ground Interface Summary

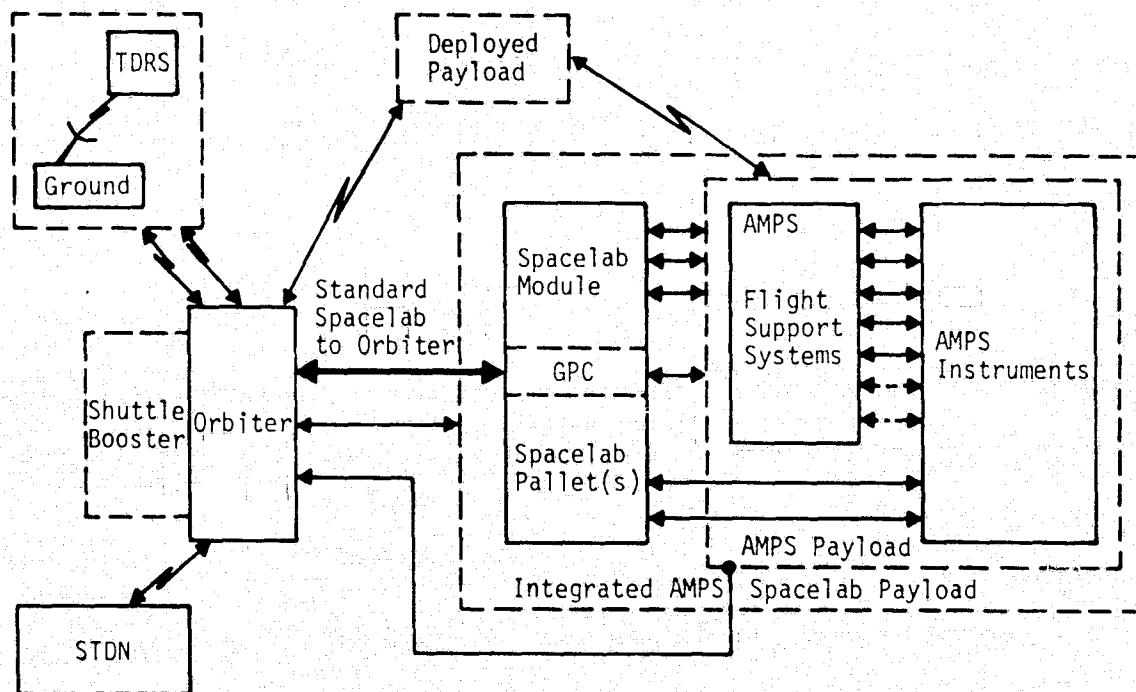


Figure 3-6 AMPS Flight Interfaces Summary

handling, transportation, storage and operations. To assure a cost effective program care shall be exercised to control the contamination only to the levels required to protect sensitive instruments and assure good data return.

Subsidiary specifications for instruments and support equipment shall include applicable requirements that assure compliance with the AMPS Program Ground Operations Contamination Control Plan (TBD) and the AMPS Program Flight Operations Contamination Control Plan (TBD).

3.9 LOGISTICS

The AMPS logistics approach shall be developed based on the integrated logistics requirements. The principal elements are maintenance/refurbishment, operational technical documentation, supply, transportation/packaging, logistics training, and logistics management information. AMPS logistics shall provide for cost-effective maintenance, refurbishment, reconfiguration, spares inventory, facilities and test equipment to support the AMPS payloads during the lifetime of the project.

3.9.1 MAINTENANCE

AMPS maintenance and refurbishment will be accomplished on the ground with the payload not installed in the Shuttle Orbiter. There will be no planned on-orbit maintenance of the AMPS equipment. On-orbit replacement of selected components or modules located in the pressurized areas may be considered on a contingency basis.

3.9.2 SUPPLY

A provisioning system shall be established for AMPS that considers the overall AMPS and STS operations. This shall include the recommended spares and quantities, the location of the spares, and the location of the spares refurbishment/modification facilities. This system shall be described in the AMPS Logistics Support Plan.

3.9.3 TRANSPORTATION

The AMPS flight hardware and GSE shall be designed to be transportable by the most cost effective available government, contractor, or commercial carriers. A transportation plan shall be prepared that documents the identified transportation and handling requirements for all AMPS instruments and flight support equipment as individual elements and combined into integrated pallets/racks.

3.9.4 REFURBISHMENT

The AMPS refurbishment at the launch site shall include pallet reconfigurations, FSE modification, instrument replacement, and pallet level cleaning/decontamination. Instrument or FSE/GSE major modification shall be performed at GSFC or the contractor's facility. These associated refurbishment requirements shall be reflected in the AMPS Integration Refurbishment Plan.

3.9.5 STORAGE

AMPS hardware shall be capable of being stored in a controlled environment for extended periods with a minimum of degradation. The optimum period of storage shall be determined for individual items based on planned usage requirements and shelf life limitations.

3.9.6 FACILITIES AND FACILITY PROVISIONS

The logistics support facilities and equipment required to perform AMPS maintenance and refurbishment at the launch site, GSFC, other government-owned facilities, or at the contractor's facilities shall be as defined in the Facilities Allocation Plan. Maximum practical use shall be made of existing facilities and associated capabilities.

3.9.7 PERSONNEL AND TRAINING

An AMPS logistics personnel training and certification program shall be established for all personnel performing critical test, checkout, maintenance, inspection, shipping, handling, and operations involving AMPS hardware. This training program shall be described in the AMPS Training Plan which includes the training necessary to prepare and maintain personnel at the skill levels required to operate and maintain AMPS equipment at its specified standard of performance.

4. VERIFICATION

This section specifies the verification requirements for AMPS Program from initial development of instruments, FSE, GSE and software through recurring, reflight operations. Subsidiary specifications shall reflect the more detailed and appropriate requirements for specific Contract End Item delivery and P/L Integration.

4.1 GENERAL REQUIREMENTS

- a. The objective of the verification program shall be to demonstrate and document that the flight and ground systems satisfy their specification requirements.
- b. The AMPS test program shall be an integrated test program. The test management shall ensure this through the continuity in test activities throughout the buildup of system elements. Inherent in planning of the buildup process shall be the objective of:
 - Minimizing test duplication;
 - Maximization of standard tests;
 - Combination of tests;
 - Commonality of tests;
 - Commonality in utilization of resources;
 - Testing at highest assembly levels practical;
 - Uniformity in handling of information (management, technical).

- c. Test emphasis (use of actual test methods) shall be applied towards cost effectiveness through the application of cost/value criteria to system elements in relation to their contribution to mission safety and/or objectives.
- d. Analytical methods shall be used to support tests or in lieu of tests whenever practical to satisfy verification requirements.
- e. The verification program will confirm that hazards identified by FMEA or other analysis have been eliminated by design or reduced to an acceptable level using safety devices, warnings, or special procedures.
- f. The planning of verification program shall provide for flexibility to accommodate changes necessitated by verification results, program redirection or as a result of continuous evaluation/monitoring of the cost/value effectiveness of verification activities.
- g. After each flight, minimum testing will be performed consistent with determining that refurbishment, repairs, and reconfiguration were correct and that the system is ready for reflight. In general, testing for the next flight may be limited to that required to validate refurbishment, repairs, and configuration changes made after the previous flights.
- h. The policy regarding test documentation requirements at various management levels shall be flexible with the objective of minimizing the variety, quantity and formality of documentation required.

4.1.1 RESPONSIBILITIES

4.1.1.1 GSFC AMPS PROJECTS

- a. Shall assure that all levels of verification requirements are defined and implemented in the most cost effective way consistent with the AMPS master schedule.
- b. Shall provide direct assistance to instrument developers if programmatic considerations or available resources dictate such an approach.

4.1.1.2 INSTRUMENT DEVELOPERS

- a. Instrument developers shall have full responsibility for development, qualification, flight certification and the acceptance data package development for flight and ground equipment up to the point of acceptance by the NASA. After acceptance, the developer will support GSFC/prime contractor through the integration, launch and post-flight activities. Refurbishment support will be determined on an individual end-item basis.
- b. Specific contractual arrangements shall be made to support universities, etc., who do not have the resources necessary to satisfy Paragraph "a" above.
- c. The prime contractor shall prepare test and checkout procedures for Level IV integration. Payload verification requirements input shall be prepared in support of integrated

STS operation Levels III through I. The prime contractor shall prepare off-line procedures and be responsible for troubleshooting procedures for integrated payload verification, checkout, and post-landing activities.

4.1.2 VERIFICATION METHOD SELECTION

Verification methods shall be selected and specified for each end-item and integrated payload performance requirement. Candidate methods include analysis/assessment, similarity, and test. Selection for each performance requirement shall be on an individual basis, but this selection must support the most efficient approach to integrated payload verification. Instruments/equipment that do not lend themselves to confident verification with either of the above methods shall be subjected to comprehensive risk assessment for program approval prior to integrated testing.

4.2 PHASED VERIFICATION REQUIREMENTS

The AMPS program office shall approve all test plans and requirements prior to implementation. Emphasis shall be placed on reduction of re-test at higher assembly levels.

4.2.1 HARDWARE

All AMPS flight and ground hardware shall have verification evidence adequate to certify that its planned use and life in the AMPS program can be expected consistent with the program's acceptance criteria.

The following subsections define the categories of verification and the general application to the AMPS elements. Variations of application are anticipated for the various potential sources of AMPS equipment, such as: existing aerospace, new aerospace, existing commercial, new commercial, etc.

4.2.1.1 DEVELOPMENT

Development tests shall be used as design tools to establish design constraints, tolerances, techniques, structural limits, etc. The extent of testing and level of control are dependent on the availability of usable data. In those instances where the data are to be used to support qualification of hardware, the intent shall be so specified and appropriate program control and documentation applied.

4.2.1.2 QUALIFICATION

Qualification shall be the formal procedure that establishes the product configuration baseline of acceptable hardware. Detailed qualification verification requirements shall be developed as the basis for verifying that flight-type and ground support equipment meet the specified performance and design requirements under anticipated operational environment. Exceptions to the full qualification requirements may be made on an individual basis once the exact configuration has been designed. The method of similarity may be used to waive qualification by test, if, it can be demonstrated, by review of prior test data or application that the article is similar or identical in design and manufacturing process to another

article previously qualified to equivalent or more stringent environmental criteria.

4.2.1.3 INITIAL ACCEPTANCE (PRELEVEL IV AND LEVEL IV)

Acceptance of AMPS end-items shall be made prerequisite to its initial operational use within the program. Any recurring verification resulting from modification, maintenance, refurbishment, or extended usage shall be determined at the highest assembly level and recertification/acceptance performed by the most practicable means as a part of the reflight operations. Candidate means for initial end-item acceptance include the following or combinations thereof:

- a. Inspection - Non-critical and simple hardware may be accepted based on workmanship and completeness of the factory process dependent on physical compliance with approved engineering;
- b. Demonstration - Some hardware may be accepted based on inspection (above) and simple demonstration consistent with the performance requirements for the end-item;
- c. Test - Critical operable hardware shall be tested (as well as items a and b) prior to delivery to GSFC, in such a manner that interface verification shall constitute verification at the next highest level of assembly. All testing shall make positive contribution to an efficient integrated payload systems test that is the culmination of AMPS flight certification independent of STS operations.

4.2.2 SOFTWARE

The software verification, validation, and certification shall be performed for the software modules and integrated levels based on the integrated software functional requirements (specifications). They shall be defined and controlled in the Software Test Plan. These test plans define both the procedures to be used and test cases which must be satisfied to ensure that the module and system satisfies the requirements. Software validation as a separate end-item shall be complete prior to integration with Spacelab Flight Systems (Level II).

4.2.2.1 DEVELOPMENT/INCREMENTAL ACCEPTANCE

Each software module shall be partially accepted prior to incorporation into the integrated AMPS software system, where final certification and acceptance is ultimately accomplished. Partial acceptance shall be based on the cumulative completion of the steps identified in section 3.1.5. These steps shall assure that the individual modules comply with:

- a. Allocated functional requirements;
- b. Module interfaces/interaction;
- c. Timing requirements;
- d. Care allocation;
- e. Critical logic; and,
- f. Proper coding.

4.2.2.2 INTEGRATED SYSTEM ACCEPTANCE

Software validation as a separate AMPS end-item shall culminate with an integrated software functional/interactive test using the software development EGSE. Specific requirements are contained in the Integrated Software Test Plan. Success criteria for this level of testing shall address the same general categories of compliance as identified for the individual modules in section 4.2.2.1.

4.2.2.3 CERTIFICATION

Final flight certification of the integrated Software System shall be accomplished jointly with the flight hardware following successful completion of an abbreviated mission simulation during STS Level II Integration (reference section 4.2.4).

4.2.3 INTEGRATED PAYLOAD SYSTEMS (LEVEL III)

Successful integrated payload testing shall certify readiness for proceeding to on-line STS flight integration at KSC. Software functions may be provided by ground software, but the flight software system shall also be ready to proceed to Level II integration with STS flight systems. Specific requirements shall be a part of the appropriate integrated payload general specification and shall, as a minimum, verify that the flight support functional interfaces and integrated operations will satisfy flight performance requirements. Scientific instrument and

zero-g hardware performance shall have been satisfactorily verified to the interface prior to this testing.

4.2.4 PRELAUNCH/STS CHECKOUT (LEVELS II AND I)

AMPS verification during these activities shall be directed at verification of the required support from the Spacelab and Orbiter flight systems. Final AMPS flight certification shall be accomplished by an abbreviated mission simulation prior to Orbiter integration. Integrated payload requirements (developed by the prime contractor and approved by the AMPS Program) and procedural inputs shall be provided to the STS integration organizations. AMPS flight crew participation is mandatory prior to certification completion.

4.2.5 POST FLIGHT

Flight data evaluation and assessment of any deterioration of AMPS payload as a result of mission use shall be accomplished to determine the degree of success in the verification of design requirements. Refurbishment and turnaround time will have been established and updated at this point in the operations cycle.

4.3 TEST SUPPORT REQUIREMENTS

4.3.1 ARTICLES

Articles of flight end-items unique to testing shall be avoided

except where program benefit is clearly established and approved by the AMPS program manager.

4.3.2 FACILITIES AND EQUIPMENT

4.3.2.1 CONTRACTOR FACILITIES

No new fixed facilities are required for the AMPS Program.

4.3.2.2 CONTRACTOR EQUIPMENT AND SERVICES

End-item developers shall provide the necessary equipment and services per the appropriate end-item specifications. These specifications shall be consistent with the requirements herein (Section 3 and 4).

4.3.2.3 NASA FACILITIES, EQUIPMENT, AND SERVICES

Support by the NASA shall be consistent with the requirements contained in Sections 3 and 4, contained herein. Specific additions and modification shall be considered a part of the subsidiary specification and contract development.

5. DEFINITIONS AND ACRONYMS

5.1 DEFINITIONS

AMPS Payload - The portion of a total AMPS flight manifest that

is developed or directly acquired by the GSFC AMPS Program. Generally this includes instruments, flight support systems, selected MMSE, and selected Spacelab hardware dedicated to the AMPS Program.

AMPS Spacelab Payload - The total integrated AMPS flight manifest that includes everything contained in the Orbiter cargo bay plus other equipment, hardware and consumables located elsewhere in the Orbiter which is user unique and is not carried as part of the basic Orbiter payload support.

Instrument - A mechanical/optical/electrical device (piece of hardware) designed to measure or observe data which can be used for assessing specific scientific parameters (such as electric fields) over some desired range of values (e.g., 0-20 V).

Example: electron accelerator.

Experiment - A measurement, or series of measurements, planned or conceived to provide quantitative values of scientific parameters, obtained by one or more instruments, which can be applied to test, or gain an understanding of a particular hypothesis or theory. Example: Test the double-layer hypothesis for the origin of E B fields by injection of electron beams.

Experiment Racks - (Spacelab Term) removable Spacelab Module standard equipment racks that AMPS will use as mounting structure for AMPS electronic internal to the pressurized module.

Flight - That portion of a mission encompassing the period from launch to landing or launch to termination of the active life of a spacecraft. The term Shuttle "flight" means a single Shuttle round trip--its launch, orbital activity and return.

Flight Support Equipment - Flight hardware elements to provide AMPS peculiar man interface, instrument accommodations, and interface with Spacelab/Orbiter. These may include subsatellites, booms, controls and displays, and pointing platforms, some of which may be common, multi-program support equipment. After appropriate STS integration, this equipment became a part of the total flight support systems.

Mission - The performance of a coherent set of investigations operations to achieve AMPS program goals. This may include the Shuttle flight as well as coordinated ground based observations.

Mission Blocks - AMPS missions that are grouped for convenience of follow-on baselining and implementation.

Zero-G Hardware - Equipment that does not lend itself to complete operation prior to obtaining orbital environments.

5.2 ACRONYMS/ABBREVIATIONS

AMPS	Atmospheric, Magnetospheric, and Plasmas in Space
AMPS-PHF	AMPS Payload Handling Facility
AO	Announcement of Opportunity
CCTV	Closed Circuit Television
CEI	Contract End-Item
CEIS	Contract End-Item Specification
CRT	Cathode Ray Tube
C&W	Caution and Warning
DOMSAT	Domestic Satellite
EGSE	Electronic Ground Support Equipment

EIS	End Item Specification
EMC	Electromagnetic Compatibility
EMI	Electromagnetic Interference
ETR	Eastern Test Range
EVA	Extra-Vehicular Activity
FSE	Flight Support Equipment
FSS	Flight Support System
GN&C	Guidance, Navigation and Control
GOAL	Ground Operations Aerospace Language
GSE	Ground Support Equipment
GSFC	Goddard Space Flight Center
HAL-S	Higher Algebraic Language--Version "S"
HQ	Headquarters
AMPS-ISGS	AMPS-Instrument Systems General Specifications
JSC	Johnson Space Center
Kbps	Kilo-Bits Per Second
KSC	Kennedy Space Center
MCC	Mission Control Center
MGSE	Mechanical Ground Support Equipment
MHz	Mega Hertz
MMSE	Multi-Use Mission Support Equipment
MSFC	Marshall Space Flight Center
AMPS-MSRD	AMPS-Mission Support Requirements Document
MTU	Master Timing Unit
OPF	Orbiter Processing Facility
POC	Payload Operations Center
AMPS-PP	AMPS-Project Plan

AMPS-PS	AMPS-Program Specification
AMPS-PGS	AMPS-Payload General Specification
AMPS-UH	AMPS-User's Handbook
PIC	
POCC	Payload Operation Control Center
P/L	Payload
psi	Pounds Per Square Inch
SPF	Spacelab Processing Facility
SPS	Samples Per Second
STDN	Spaceflight Tracking and Data Network
STS	Space Transportation System
SWG	Scientific Working Group
TBD	To Be Determined
TBS	To Be Supplied
TDRSS	Tracking and Data Relay Satellite System
TV	Television
VAB	Vertical Assembly Building
VCS	Vernier Control System
WTR	Western Test Range
W/m^2	Watts Per Square Meter